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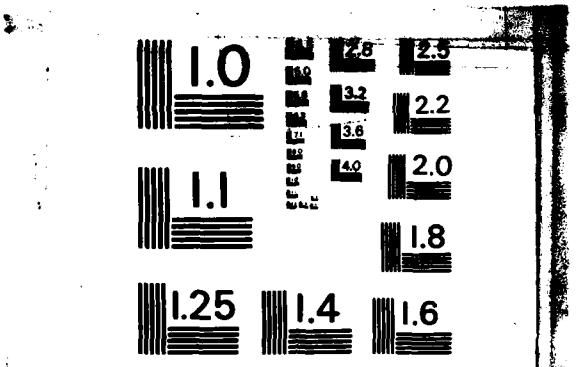

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William N. Findley

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents the results of studies of stress relaxation experiments in tension at low stresses; aging creep test; compression creep tests; non-proportional loading and unloading at low stresses; prediction from a viscous-viscoelastic model of the multiple-step non-proportional loading experiments at low stresses; the possibility of an upper limit to the recoverable strain, and the possible applicability of other theories to prediction of creep under complex stress histories.

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Final Report

on

"Prediction of Creep and Creep Relaxation of AL 2618
Under Variable Multiaxial Stresses"

BROWN UNIVERSITY, PROVIDENCE, R.I. 02912

August 10, 1981 through February 10, 1984

DAAG29-81-K-0138

by

William N. Findley

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Statement of the Problem Studied

Information available for developing constitutive equations for use in design in critical applications involving variable stress states is limited largely to uniaxial states of stress. This is insufficient information. In addition to the experimental results and analysis previously reported on 2618 aluminum alloy, the following problems were proposed to be studied: stress relaxation experiments in tension at low stresses; aging creep test; compression creep tests; non-proportional loading and unloading at low stresses; prediction from a viscous-viscoelastic model of the multiple-step non-proportional loading experiments at low stresses; investigation of the possibility of an upper limit to the recoverable strain; and investigation of the possible applicability of other theories to prediction of creep under complex stress histories.

Summary of Important Results

A set of creep experiments on 2618-T61 aluminum were performed at several combinations of tension and torsion, and compression at various stresses and at 200°C. Major loading steps were of 48h duration. Data were represented by a viscous-viscoelastic model. Time dependence was represented by a power function of time with different exponents for recoverable and nonrecoverable components.

Experiments showed: that aging was negligible within the testing period of 312h; that there was symmetry between tension and compression; and there was no true creep limit so a homogeneous function of maximum shear stress was developed to represent the full range of stress dependence.

Multistep creep tests were performed using both proportional and non-proportional loading to evaluate hardening theory and viscoelastic behavior. A viscoelastic type component of strain was necessary to describe the observed behavior on removal of stress, partial reduction of stress or reloading.

A synergistic effect resulting from adding torsion (for example) during creep recovery was not predicted by any theory considered. The behavior is evidently due to the combined effect of internal stresses and applied stresses.

Isotropic strain hardening generally yields better prediction of creep under complex stress history than kinematic hardening.

Stress Relaxation experiments are essentially variable stress creep tests and showed similar behavior characteristics under changing complex straining as found in creep tests. A strain hardening theory was better than kinematic hardening for stress relaxation.

Creep experiments at constant stress under variable temperature were performed using both step temperature changes and linearly increasing and decreasing temperature. It was found that the creep behavior under variable temperature was well described by using a temperature compensated time proposed by Sherby and Dorn.

Publications and Technical Reports

Technical Reports:

No. 1 "48 Hour Multiaxial Creep and Recovery of 2618 Aluminum Alloy at 200°C," by Jow-Lian Ding and William N. Findley.

No. 2 "Multiaxial Creep of 2618 Aluminum Under Proportional Loading Steps," by Jow-Lian Ding and William N. Findley.

No. 3 "Creep and Creep Recovery of 2618-T61 Aluminum Under Variable Temperature," by U. W. Cho and W. N. Findley.

Publications:

"48 Hour Multiaxial Creep and Recovery of 2618 Aluminum at 200°C," by J. L. Ding and W. N. Findley, to be published in Journal of Applied Mechanics.

"Multiaxial Creep of 2618 Aluminum Under Proportional Loading Steps," by J. L. Ding and W. N. Findley, to be published in Journal of Applied Mechanics.

"Creep and Creep Recovery of 2618-T61 Aluminum Under Variable Temperature," U. by W. Cho and W. N. Findley, to be published in Journal of Applied Mechanics.

Submitted for Publication:

"Nonproportional Loading Steps in Multiaxial Creep of 2618 Aluminum," by J. L. Ding and W. N. Findley.

"Creep Experiments Under Nonproportional Loadings with Stress Reversals for 2618 Aluminum," by J. L. Ding and W. N. Findley.

"Theory and Comparison with Creep Experiments Under Nonproportional and Reversed Stressing," by J. L. Ding and W. N. Findley.

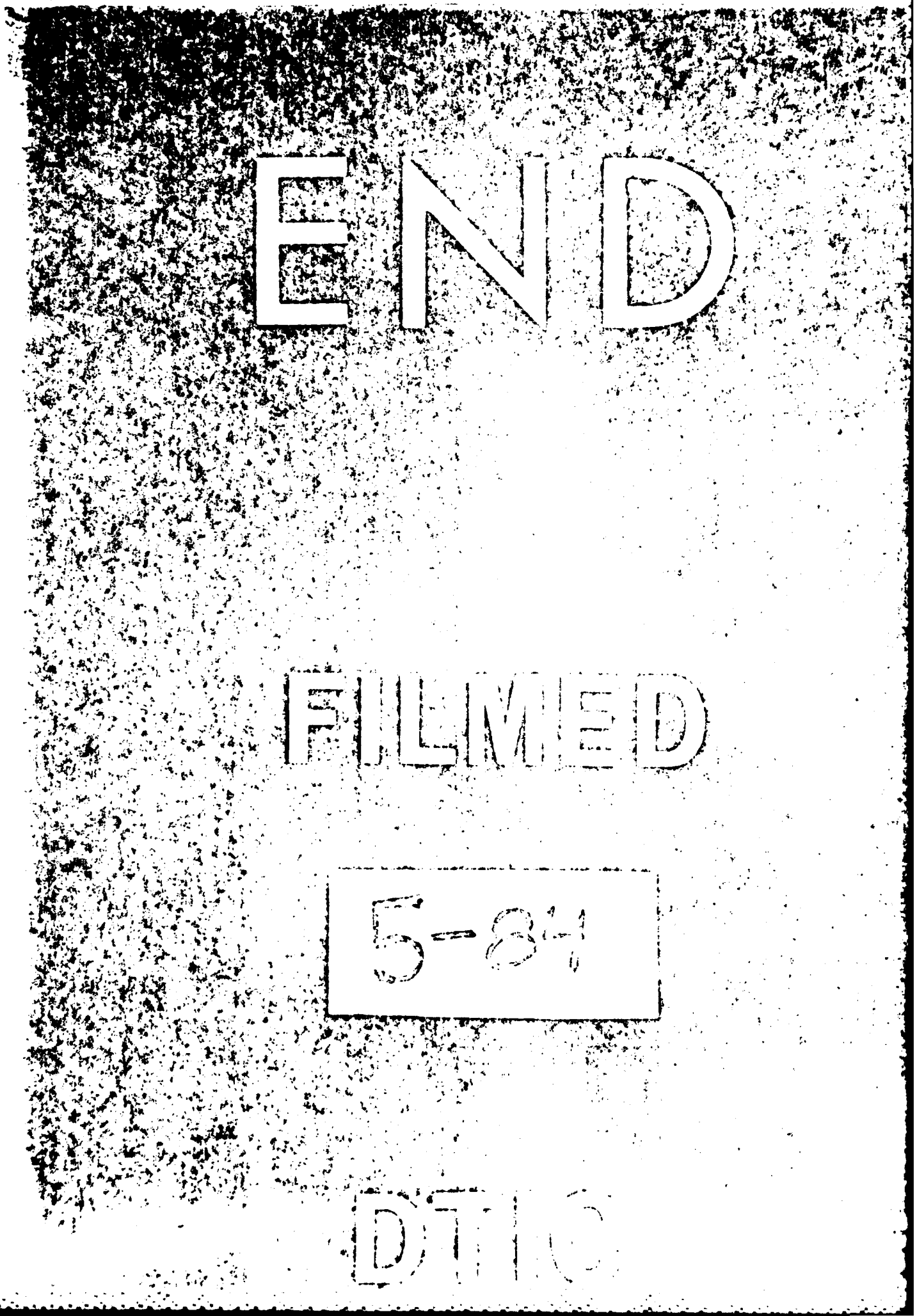
"Simultaneous and Mixed Stress Relaxation in Tension and Creep in Torsion of 2618 Aluminum," by J. L. Ding and W. N. Findley.

SCIENTIFIC PERSONNEL

W. N. Findley — Professor of Engineering, Brown University
Principal Investigator

J. L. Ding — Research Assistant, Brown University. Ph.D. degree completed under ARO sponsorship August, 1983, to be conferred, June, 1984. Present address: Assistant Professor, Department of Mechanical Engineeering, Washington State University, Pullman, Washington 99164.

U. W. Cho — Assistant Professor of Mechanical and Aerospace Engineering, University of Missouri-Columbia, Columbia, Missouri 65211.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